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TISSUE AND TOWELING PAPERS FROM MIXTURES OF PHILIPPINE HARDWOODS

By

James F. Laundrie
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Donald J. Fahey

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FOREST PRODUCTS LABORATORY
MADISON 5, WISCONSIN

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
In Cooperation with the University of Wisconsin

TISSUE AND TOWELING PAPERS FROM MIXTURES OF PHILIPPINE HARDWOODS

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James F. Laundrie
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Donald J. Fahey

Forest Products Laboratory,[1] Forest Service
U.S. Department of Agriculture

Summary

This report establishes the suitability of Philippine hardwoods for the manufacture of tissue and toweling papers. Acceptable quality papers were made from furnishes containing 80 percent Philippine hardwood kraft pulp and 20 percent commercial long-fibered pulp. No significant changes in the quality of the papers were found in replacing half of the hardwood kraft pulp with a Philippine hardwood thermomechanical pulp.

Experimental

Wood Mixtures

Fifty species of Philippine hardwoods were used to make pulps for the tissue and toweling paper machine trials. The chips were made from bark-free wood in a commercial size, four-knife chipper. The nominal length of the chips was 5/8 inch, and the fines and oversize were removed prior

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[1]Maintained in Madison, Wis., in cooperation with the University of Wisconsin.

to blending of the individual species to obtain the mixtures. The mixture for the kraft pulp contained equal amounts (dry-weight basis) of 47 species listed in Table 1. As shown in Table 2, the mixture for the thermomechanical pulp contained equal amounts of the three lightest colored woods.

Kraft Pulping

Based on the results of preliminary kraft pulping studies made with mixtures of all 50 species combined in three different specific gravity distributions (AID Report No. 1), the following conditions were chosen to make pilot-scale digestions:

(a) 16.0 percent active alkali.

(b) 25 percent sulfidity.

(c) 4-to-1 water-to-wood ratio.

(d) 90 minutes to raise the temperature to 170° C.

(e) 90 minutes at 170° C.

Chips with a dry weight of 140 pounds were used in each pilot-scale digestion. At the end of cooking, the digester was blown. The resulting pulp was washed, screened through a 0.012-inch slotted flat screen, and wet lapped. The composite pulps had a Kappa number of 22.8.

Thermomechanical Pulping

The mixture of light-colored chips was converted into thermomechanical pulp at the pilot plant of C. E. Bauer, Springfield, Ohio. The chip mixture was given an initial 2-minute steaming at 30 p.s.i.g. and then fiberized to about 400 Canadian Standard freeness in a

418-pressurized refiner. This high-freeness pulp was returned to the Forest Products Laboratory (FPL) in order for us to have better control and more flexibility in subsequent refining stages to develop optimum properties of this pulp for use in various papers.

Preliminary atmospheric refining trials made with this high-freeness pulp in a 36-inch disk mill indicated that it was necessary to lower the freeness to about 125 Canadian Standard freeness in order to develop optimum properties. Consequently, the larger batches of pulp for the paper machine trials were refined to this freeness.

Bleaching

The Philippine hardwood kraft pulp was bleached to a brightness of 86.7 percent in a five-stage bleach consisting of chlorination, extraction, chlorine dioxide, extraction, and chlorine dioxide. The conditions are given in Table 3.

The thermomechanical pulp made from the three-species mixtures was too low in brightness for use in tablet papers, and it was therefore bleached to a brightness of 72.0 percent using a one-stage bleach of hydrogen peroxide. Bleaching conditions are given in Table 4. During the pressurized thermomechanical fiberizing stage, stresses are developed in the fibers. A recommended procedure for relieving these stresses is heating of the pulp slurry above 70° C. and agitating until a constant freeness value is reached. This so-called "latency" was effectively removed from the thermomechanical pulp under the conditions used to make the bleach.

Papermaking

Experimental 12-pound facial tissue, 14-pound toilet tissue, and 30-pound toweling were made from furnishes containing (a) 80 percent Philippine hardwood kraft pulp and (b) 40 percent of this kraft pulp and 40 percent Philippine hardwood thermomechanical pulp. In addition, toweling was made from 30 percent Philippine hardwood kraft, 60 percent thermomechanical pulp, and 10 percent long-fiber kraft pulp. The remainder of each furnish consisted of a commercial long-fiber kraft pulp. The facial tissues were dry creped at 95 percent solids or above with 0.05 percent of a polyamide resin added to the furnish for better adhesion at the creping dryer. The toilet tissue was wet creped at about 53 percent solids and the toweling at 50 to 60 percent. The toweling furnishes had 0.25 percent of a wet strength resin added continuously. The pH of all furnishes was adjusted to 7.0 with acid because of the high alkalinity of Madison city water. The all-kraft furnish was jordan refined to a Canadian Standard freeness of about 540 milliliters. Those furnishes containing thermomechanical pulp were already at a low freeness and thus received no processing.

For comparison purposes, tissue and toweling were also made on the experimental paper machine using a furnish of 80 percent hardwood bleached kraft pulp and 20 percent of the long-fiber kraft pulp both obtained from North American manufacturers. This furnish was also jordan refined to about 540 milliliters. The commercial kraft pulps were received in air-dried lap form. The Philippine hardwood kraft pulp used in these experiments consisted of equal parts of never-dried pulp and pulp dried to about 80 percent solids content.

Results

Pulp Properties

The handsheet properties of both the unbleached and bleached Philippine hardwood kraft pulps are given in Table 5. As was found in previous work with other tropical hardwood mixtures, the quality of these pulps was better than that of kraft pulps made from North American hardwood mixtures. Bleaching of the Philippine hardwood kraft pulp with CEDED increased the tearing resistance about 10 percent while maintaining the bursting and tensile strengths. The strength properties of the commercial western Canadian softwood bleached kraft pulp and the commercial southern U.S. hardwood bleached kraft pulp are given in Table 6, and those of the bleached thermomechanical pulp are given in Table 7.

Tissue and Toweling Papers

Results for the various experimental papers are presented in Table 8. Samples of the papers are included in the report. Properties of "weigh sheets" taken directly from a commercial paper machine prior to converting are also included in the table.

A soft, absorbent facial tissue was made with 80 percent Philippine hardwood kraft pulp. This tissue was somewhat better in these characteristics than the reference tissue made with commercial hardwood kraft pulp, which in turn was better than the "weigh sheets." Its cross machine tensile strength was slightly lower than the experimental reference but better than that of the "weigh sheets."

Replacing half of the Philippine hardwood kraft pulp with the Philippine hardwood thermomechanical pulp resulted in a less soft and absorbent facial tissue but still softer than the "weigh sheets." It had good strength properties.

Good-quality toilet tissues were also made with the Philippine hardwoods. The 80-20 Philippine hardwood kraft and long-fiber sheet had the best softness, and its absorbency was comparable to the experimental reference. While its strength was slightly lower than the experimental reference, it was somewhat stronger than the "weigh sheet." Adding thermomechanical pulp lowered the softness and absorbency, but the strength was better.

The toweling paper made with 80 percent Philippine hardwood kraft pulp had more than adequate strength, but it was not as soft or as absorbent as the experimental control. With less processing, better softness and absorbency undoubtedly could be obtained at a sacrifice of some of the excess strength. An improvement in both these characteristics was found to take place when half of the kraft pulp was replaced with thermomechanical pulp. However, increasing the amount of thermomechanical pulp in the furnish from 40 to 60 percent had a slight, adverse effect on both softness and absorbency, but not on strength. All of the experimental toweling papers easily met the requirements specified by the Government in Federal Specification UU-T-591d for paper towels.

Conclusions

Acceptable sanitary tissue and toweling papers can be made using as much as 80 to 90 percent Philippine hardwoods. Thermomechanical pulp can be used in place of part of the kraft with no significant changes in the quality of the papers.

Table 1.--Names and Specific Gravities of the Philippine Hardwood Mixture Used to Make Kraft Pulp

Common name	Botanical name	Specific gravity
Tangisang-bayauak	Ficus variegata	0.236
Binuang	Octomeles sumatrana	.242
Kapok	Ceiba pentandra	.244
Balilang-uak	Meliosma macrophylla	.260
Kaitana	Zanthoxylum rhetsa	.296
Ilang-ilang	Cananga odorata	.308
Anabiong	Trema orientalis	.319
Hamindang	Macaranga bicolor	.324
Balanti	Homalanthus populneus	.356
Mayapis	Shorea squamata	.366
Matang-arau	Melicope triphylla	.381
Malasantol	Sandoricum vidalii	.394
White lauan	Pentacme contorta	.401
Tulo	Alphitonia philippinensis	.422
Tangile	Shorea polysperma	.429
Pahutan	Mangifera altissima	.435
Apanit	Mastixia philippinensis	.447
Lago	Pygeum vulgare	.451
Antipolo	Artocarpus blancoi	.469
Bagtikan	Parashorea plicata	.478
Sakat	Terminalia nitens	.485
Red Lauan	Shorea negrosensis	.510
Itangan	Weinmannia luzoniensis	.526
Piling-liitan	Canarium luzonicum	.549
Palosapis	Anisoptera thurifera	.554
Lomarau	Swintonia foxworthyi	.559
Malabetis	Madhuca oblongifolia	.560
Dangkalan	Calophyllum obliquinervium	.568
Panau	Dipterocarpus gracilis	.576
Katmon	Dillenia philippinensis	.592
Batitinan	Lagerstroemia piriformis	.597
Katong-lakihan	Amoora macrophylla	.608
Narig	Vatica mangachapoi	.618
Miau	Dysoxylum euphlebium	.623
Apitong	Dipterocarpus grandiflorus	.623

(Sheet 1 of 2)

Table 1.--Names and Specific Gravities of the Philippine Hardwood Mixture Used to Make Kraft Pulp--Con.

Common name	Botanical name	Specific gravity
Bok-bok	Xanthophyllum excelsum	0.639
Kamatog	Erythrophloeum densiflorum	.650
Dalingdingan	Hopea foxworthyi	.667
Katilma	Diospyros nitida	.679
Yakal	Shorea astylosa	.718
Kamagong	Diospyros philippinensis	.720
Katong-Matsin	Chisocheton pentandrus	.725
Manaring	Lithocarpus soleriana	.736
Ipil-ipil	Leucaena leucocephala	.737
Bolong-eta	Diospyros pilosanthera	.743
Makaasim	Syzygium nitidum	.778
Alupag-amo	Litchi philippinensis	.793

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Table 3.--Bleaching of Philippine Hardwood Kraft Pulp Used in Tissue and Toweling Papers

Stage	Chlorination	Extraction	Dioxide	Extraction	Dioxide
Chemical:					
Formula	Cl_2	NaOH	ClO_2	NaOH	ClO_2
Amount applied...pct:	5.5	2.0	0.76	1.0	0.38
Temperature.........°C:	25	71	68	50	70
Consistence........pct:	1.9	10.6	4.0	10.9	3.6
Duration..........min:	60	60	120	60	180
pH:					
Initial.............:	2.8	11.4	--	11.8	--
Final...............:	2.7	11.3	6.7	11.6	6.5
Brightness.........pct:	--	--	--	--	86.7

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Table 4.--Bleaching of Philippine Hardwood Thermomechanical Pulp Used in Tissue and Toweling Papers

Chemical:	
Formula	H_2O_2
Amount applied....pct:	0.96
Amount consumed....pct:	0.87
Temperature....°C:	73
Consistence....pct:	9.6
Duration....min:	300
pH:	
Initial	10.3
Final	9.3
Brightness:	
Orginal....pct:	54.7
Final....pct:	72.0

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Table 5.--Handsheet Properties of Unbleached and Bleached Philippine Hardwood Kraft Pulps Used in Tissue and Toweling Papers

Properties	Unbleached				Bleached			
eating time..........min	0	14	27	42	0	13	29	37
reeness (CSF).........ml	615	505	390	240	580	480	335	230
urst factor.............	32	54	70	82	28	46	65	72
ear factor..............	116	121	115	108	130	132	129	125
reaking length........km	6.8	9.7	10.6	12.3	4.9	7.2	9.6	10.2
pparent density....g/cm^3	0.56	0.62	0.66	0.70	0.62	0.64	0.70	0.70
rightness...........pct	25.1	--	--	--	86.7	--	--	--

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Table 6.--Handsheet properties of commercial bleached kraft pulps used in tissue and toweling papers

Properties	Softwoods--western Canada				Hardwoods--southern U.S.			
ating time.........min	0	22	43	64	0	17	33	43
eeness (CSF)........ml	665	530	415	275	680	570	375	245
rst factor...........	24	75	96	104	11	32	54	57
ar factor............	248	114	110	108	100	117	112	106
eaking length.......km	4.1	9.4	11.3	12.6	3.0	6.1	8.0	8.6
parent density...g/cm^3	0.61	0.67	0.72	0.73	0.55	0.63	0.68	0.69
ightness..........pct	86.5	--	--	--	89.4	--	--	--

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Table 7.--Handsheet properties of bleached Philippine Hardwood Thermomechanical Pulp Used in Tissue and Toweling Papers

Freeness (CSF)................ml:	170
Burst factor....................:	9.8
Tear factor.....................:	40.3
Breaking length...............km:	2.5
Apparent density...........g/cm^3:	0.44
Brightness..................pct:	71.4
Scattering coefficient..........:	630
Opacity.....................pct:	88.0

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Table 8.--Properties of Tissue and Toweling Papers

Machine run No.	Bleached pulp furnish: Philippine hardwood: Kraft	Philippine hardwood: TMP[3]	Commercial kraft: Hardwood	Commercial kraft: Softwood	Stuff freeness (CS)	Weight: Square meter	Weight: 24x36, : 500	Thickness[2]	Bursting strength	Tensile strength: Dry: Machine direction	Tensile strength: Dry: Cross direction	Tensile strength: Wet: Machine direction	Tensile strength: Wet: Cross direction	Stretch: Machine direction	Stretch: Cross direction	Water absorbency (0.1 cm^3)	Softness: Machine direction	Softness: Cross direction	Softness: Overall	Brightness (Elrepho)
	Pct	Pct	Pct	Pct	Ml	G	Lb	Mils	Pts	P.i.w.	P.i.w.	P.i.w.	P.i.w.	Pct	Pct	S				Pct
NOMINAL 12-POUND DRY-CREPED FACIAL TISSUE[4]																				
Commercial "weigh sheet"[5]						17.6	10.8	2.8	1.18	1.01	0.31	--	--	20.8	4.9	--	400	144	240	84.2
[6]7127	--	--	80	20	550	19.0	11.7	3.3	1.59	.78	.53	0.09	0.07	25.2	2.4	69.4	1,686	170	535	84.8
7129	80	--	--	20	540	18.4	11.3	3.1	1.03	.42	.44	.11	.09	21.4	2.5	46.4	5,649	248	1,184	83.7
[7]7132	40	40	--	20	460	22.1	13.6	3.5	2.18	1.03	.83	.19	.19	27.6	2.8	65.2	1,346	130	418	73.8
NOMINAL 14-POUND WET-CREPED TOILET TISSUE																				
Commercial "weigh sheet"[5]						21.3	13.1	3.1	.85	.67	.33	--	--	18.8	3.3	--	376	100	195	76.8
[6]7125	--	--	80	20	520	21.2	13.0	3.3	3.45	1.53	1.05	--	--	7.4	2.0	30.4	434	213	304	87.6
7130	80	--	--	20	540	21.0	12.9	3.1	2.66	1.15	1.00	--	--	6.0	2.6	31.1	391	451	420	83.2
[7]7133	40	40	--	20	460	23.8	14.6	4.1	3.08	1.66	1.26	--	--	10.2	2.0	49.8	374	189	266	74.2
NOMINAL 30-POUND WET-CREPED TOWELING PAPER[8]																				
Commercial "weigh sheet"[5]						55.0	33.8	7.4	4.90	3.40	2.40	.97	.58	9.9	3.2	10.0	26	12	18	--
[6]7126	--	--	80	20	520	48.9	30.0	6.5	6.60	6.42	3.88	--	--	10.4	--	12.6	102	20	45	87.8
7131	80	--	--	20	540	49.4	30.4	5.9	12.80	8.60	7.50	2.20	1.70	7.9	--	33.8	39	17	26	--
[7]7134	40	40	--	20	460	48.9	30.0	6.2	8.80	6.40	5.20	1.70	1.10	7.4	--	18.4	47	23	33	72.8
[7]7135	30	60	--	10	370	52.6	32.3	8.1	8.00	7.76	6.30	2.07	1.45	8.4	2.3	24.1	40	8	18	70.2

Properties[1]

[1]Tested according to TAPPI Standard Methods.

[2]Crepe not removed.

[3]Thermomechanical pulp.

[4]0.05 percent polyamide resin added to furnish for better adhesion to creping dryer.

[5]Supplied by U.S. manufacturer from commercial runs for converting to the consumer grade.

[6]Control.

[7]Furnishes received no processing; others refined with jordan on the machine.

[8]0.25 percent wet-strength resin added to furnish, except run 7126.

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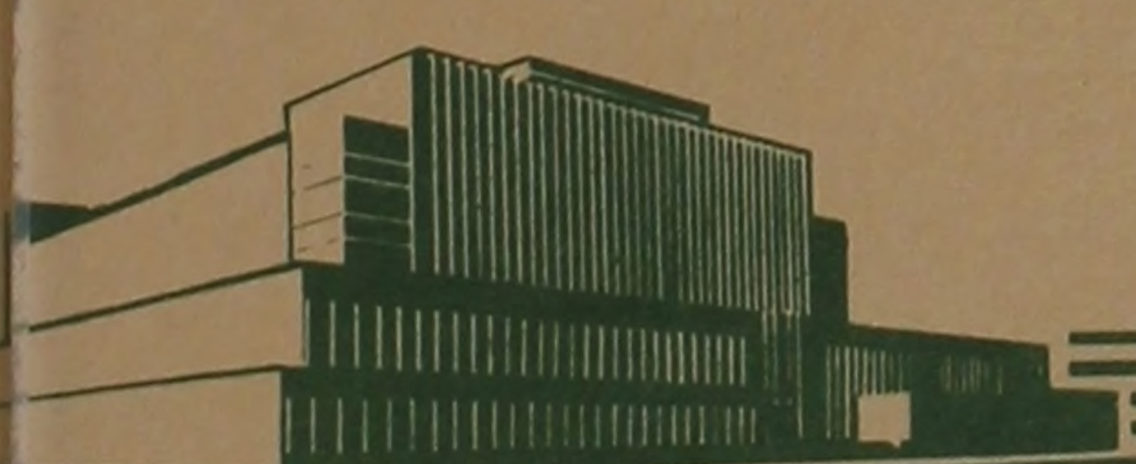

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G. C. Myers
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Summary

This report establishes the suitability of Philippine hardwoods for the manufacture of hardboard. Low energy was required to fiberize the chips into hardboard fiber. High-density hardboards, made from several chip mixtures by both the dry- and wet-formed processes, easily met the Voluntary Product Standard for standard hardboard. Dry-formed, medium-density hardboard made with urea resin had strength properties suitable for furniture core stock. Medium-density hardboard made with phenol-resorcinol resin had strength and accelerated aging properties suitable for exterior siding application. All hardboards had excellent surface characteristics, which are desirable in finishing.

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[1]Maintained in Madison, Wis., in cooperation with the University of Wisconsin.

Experimental

Wood Mixtures

Fifty species of Philippine hardwoods (Table 1) were used to make the pulps for the hardboard trials. The chips were made from bark-free wood in a commercial size, four-knife chipper. The nominal length of the chips was 5/8 inch, and the fines and oversize material were removed prior to blending of individual species to obtain the three mixtures described in Table 2. Mixture "A" contained an even distribution of all species, while mixture "B" was weighted with more of the high-density species and mixture "C" with the intermediate-density species. The weighted average specific gravity of the three mixtures was 0.505, 0.643, and 0.538, respectively. Chip mixtures "A" and "B" were air classified to obtain a light and heavy chip fraction using an arbitrary specific gravity of 0.50 as the separation point.

Pulp Preparation

Chips were converted into hardboard quality pulp using (1) a small batch-type Asplund Defibrator at the Forest Products Laboratory (FPL) and (2) a Bauer 418 pressurized refiner in the pilot plant of C. E. Bauer, Springfield, Ohio. Asplund pulps with yields of 88 to 90 percent were made from each of the three chip mixtures and from the heavy and light chip fraction of mixture "B." The chips were given an initial 3-minute steaming at 175 pounds per square inch followed by a 3.5- to 4-minute fiberizing in the mill at 125 pounds per square inch. In addition, 80 to 82 percent yield pulp was also made from (1) mixture "B,"

(2) oversize and undersize screenings from mixture "B," and (3) 50-50 blend of screenings and chips from mixture "B." These pulps were prepared at 13.5 to 14 minutes of steaming at 175 pounds per square inch followed by 2 minutes of fiberizing at 125 pounds per square inch. Bauer-refined pulp at a yield of about 90 percent was made from chip mixtures "A" and "B" and from the heavy chip fraction of mixture "B." These were subjected to 3.5 minutes of steaming at 85 pounds per square inch. Only 2.1 to 2.9 HPD/ADT was used in producing these pulps, which is somewhat less than that required to produce similar pulp from U.S. wood species.

Boardmaking

Dry-formed, 1/8-inch, high-density hardboards were made at FPL from pulps prepared in the Asplund Defibrator and in the Bauer refiner. The pulps were first air dried. They were then sprayed with either 2 or 4 percent resin by weight, based on the pulp, while tumbling in a rotating drum. The resin was a phenol-formaldehyde type commonly used for dry-formed hardboard. Fourteen- by fourteen-inch mats were formed on a banjo-type former, cold pressed, and then hot pressed between platens at a temperature of 375° F. for 6 minutes.

Wet-formed, 1/8-inch, high-density hardboards were also made at FPL. The pulp in a water slurry was treated with 1 percent phenol-formaldehyde resin of a type commonly used for wet-formed hardboards and 0.75 percent wax size. Eight-inch-diameter mats were formed in the Asplund Drainage Tester, cold pressed, and then hot pressed at a platen temperature of 375° F. for 6 minutes.

Dry-formed, medium-density hardboards, approximately 32 by 34 inches, were made in the pilot plant of Miller-Hofft, Richmond, Va. The fiber was flash dried and then treated with 1 percent wax size and 8 percent urea-melamine resin or phenol-resorcinol resin. The mats were pressed in a high-frequency press and the boards shipped to FPL.

All of the high-density hardboards and the medium-density hardboards made with phenol-resorcinol resin were exposed to a further heat treatment by exposing them for 1 hour in a circulating-air oven at 320° F.

Test Methods

Evaluations were made on test specimens preconditioned 30 days at 50 percent relative humidity and 73° F. using test procedures specified in ASTM Standard D 1037-72a(1) with the following exception. Dimensional movement was determined on 1/2- by 6-inch specimens preconditioned for 30 days at 50 percent relative humidity and then exposing them to the following conditions: (1) 90 percent relative humidity and 80° F. for 30 days, (2) immersion in water for 30 days, and (3) drying in an oven at 220° F. for 72 hours. Length, thickness, and weight changes were determined before and after exposure to each condition.

Results

High-Density Hardboard

Dry-formed.--The dry-formed hardboards made with the high-yield Asplund pulp easily met the requirements of Voluntary Product Standard PS58-73(2) for standard hardboard (Table 3) for those properties

evaluated. Boards from chip mixtures "A" and "C" were comparable in all strength properties and in linear movement. Their strength properties were generally somewhat better than for the boards made with chip mixture "B," which had the higher average density.

When comparing boards made with the light and heavy chip fractions of mixture "A," slightly better strengths were obtained with the lighter weight fraction. Surprisingly, the heavier weight fraction produced slightly more linearly stable boards.

Except for possibly improved thickness swelling, no advantage was realized by reducing the pulp yield from about 90 to 80 percent. The boards made with the lower yield pulp exhibited not only more linear movement, but they were not as strong.

Hardboard was considered as a possible outlet for the screenings from the chipping operation. The board made from 100 percent screenings (mixture of both oversize and undersize material) was somewhat lower in bending and tensile strengths than board produced with the same chip mixture. Blending screening rejects with an equal amount of chips, by weight, from the same species mixture resulted in an improvement in strength, but the improvement was not enough to meet the requirements for standard hardboard specified in the Product Standard. With a greater percentage of regular chips or a higher yield pulp, it may be possible to produce acceptable boards with screenings.

The dry-formed hardboards made with the Bauer-refined pulp were generally superior to the boards made from the same yield Asplund pulp. While those made with 2 percent resin binder were usually not as strong

as those made with 4 percent binder, they still were somewhat stronger than required to meet the Product Standards. The results indicate that somewhat less than 2 percent binder will be needed to produce acceptable high-density board. The linear movement of all the Bauer-refined boards was extremely small, but they expanded more in thickness than the dry-formed boards prepared with Asplund pulp.

Wet-formed boards.--Good quality wet-formed boards were made with 1 percent resin addition. The boards with Bauer-refined pulp from chip mixtures "A" and "B" easily met the requirements of the Product Standard for those properties evaluated. The board with heavy fraction of chips from mixture "B" lacked adequate internal bond strength. This could undoubtedly be overcome with an increase in the amount of resin binder.

Medium-Density Hardboards

Medium-density hardboards of good quality were made from chip mixtures "A" and "B" (Table 4). The 3/4-inch-thick boards bonded with urea-melamine resin had good surface and edge characteristics and good linear stability, desirable properties for use in furniture. While they did not possess as high strength and stiffness as commercial boards now used by the furniture industry in the United States, these properties are of secondary importance for many furniture applications. If more strength is needed, this can undoubtedly be achieved with an increase in board density or with the addition of more resin binder. Little difference was noted in board quality between chip mixtures "A" and "B," and the heavy chip fraction of mixture "B." There was also little difference observed in board properties when the urea binder system

contained 6, 15, or 35 percent melamine resin. The higher melamine levels were considered a possible benefit under wet conditions. The results showed, however, the amount of melamine to have little or no effect even on wet properties. These experimental boards had greater thickness swelling after a 24-hour water soaking than the commercial boards, indicating that perhaps more wax sizing will be required with the Philippine hardwood mixtures than with domestic U.S. species.

The 7/16-inch 48-pound- and 1/2-inch 50-pound-per-cubic-foot density boards were investigated as potential products for siding. Those bonded with phenol-resorcinol resin had good characteristics for exterior use. They retained a reasonable amount of their initial strength both after water soaking and after accelerated aging. The boards bonded with the urea-melamine resin system retained only a small quantity of their original strength and would therefore not be desirable for exterior applications. Chip mixture was again found to have little or no effect on the performance of these medium-density boards.

Dimensional stability specimens exposed for 30 days at 90 percent relative humidity developed varying degrees of mold growth. All specimens from the 3/4-inch-thick boards made with chip mixtures "A" and "B" using the urea binder containing 6 percent melamine developed a heavy mold growth. A similar amount of growth was noted on some of the 7/16-inch-thick specimens made with chip mixture "A" and bonded with urea containing 35 percent melamine. This could be a problem when using these boards in an area which remains very humid for long periods of time.

In producing these medium-density boards, it was noted that the bulk density of the mats formed from the different wood mixtures was about the same. This has not necessarily been the case when using different domestic wood species. From a quality control standpoint, it is highly desirable in production that the bulk density remain constant so as to maintain uniform board weight and density.

More time was required in pressing the phenol-resorcinol bonded boards in the high-frequency press than the urea-melamine boards. To completely cure the phenol-resorcinol required a further heat treatment of the boards.

Conclusions

(1) The mixed Philippine hardwoods can be easily converted into good quality pressurized refined pulp, consuming less energy than required for most U.S. species.

(2) Different Philippine hardwood mixtures can be used with minimal effect on hardboard quality.

(3) Good quality high-density hardboards can be made by either the dry- or wet-forming process.

(4) Medium-density hardboards from the mixed tropical woods, when bonded with conventional urea resin systems, are suitable for furniture use and, when bonded with phenol-resorcinol, are sufficiently durable for exterior use.

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   1973. Basic hardboard. Voluntary Product Standard PS 58-73, U.S. Dep. Commerce.

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Table 1.--Names and specific gravities of the Philippine hardwood mixture used to make hardboards

No.	Common name	Botanical name	Specific gravity
1	Tangisang-bayauak	Ficus variegata	0.236
2	Binuang	Octomeles sumatrana	.242
3	Kapok	Ceiba pentandra	.244
4	Balilang-uak	Meliosma macrophylla	.260
5	Rarang	Erythrina subumbrans	.264
6	Kaitana	Zanthoxylum rhetsa	.296
7	Ilang-ilang	Cananga odorata	.308
8	Gubas	Endospermum peltatum	.316
9	Dita	Alstonia scholaris	.316
10	Anabiong	Trema orientalis	.319
11	Hamindang	Macaranga bicolor	.324
12	Balanti	Homalanthus populneus	.356
13	Mayapis	Shorea squamata	.366
14	Matang-arau	Melicope triphylla	.381
15	Malasantol	Sandoricum vidalii	.394
16	White lauan	Pentacme contorta	.401
17	Tulo	Alphitonia philippinensis	.422
18	Tangile	Shorea polysperma	.429
19	Pahutan	Mangifera altissima	.435
20	Apanit	Mastixia philippinensis	.447
21	Lago	Pygeum vulgare	.451
22	Antipolo	Artocarpus blancoi	.469
23	Bagtikan	Parashorea plicata	.478
24	Sakat	Terminalia nitens	.485
25	Red lauan	Shorea negrosensis	.510
26	Itangan	Weinmannia luzoniensis	.526
27	Piling-liitan	Canarium luzonicum	.549
28	Palosapis	Anisoptera thurifera	.554
29	Lomarau	Swintonia foxworthyi	.559
30	Malabetis	Madhuca oblongifolia	.560

(Sheet 1 of 2)

Table 1.--Names and specific gravities of the Philippine hardwood mixture used to make hardboards--Con.

No.	Common name	Botanical name	Specific gravity
31	Dangkalan	Calophyllum obliquinervium	0.568
32	Panau	Dipterocarpus gracilis	.576
33	Katmon	Dillenia philippinensis	.592
34	Batitinan	Lagerstroemia piriformis	.597
35	Katong-lakihan	Amoora macrophylla	.608
36	Narig	Vatica mangachapoi	.618
37	Miau	Dysoxylum euphlebium	.623
38	Apitong	Dipterocarpus grandiflorus	.623
39	Bok-bok	Xanthophyllum excelsum	.639
40	Kamatog	Erythrophloeum densiflorum	.650
41	Dalingdingan	Hopea foxworthyi	.667
42	Katilma	Diospyros nitida	.679
43	Yakal	Shorea astylosa	.718
44	Kamagong	Diospyros philippinensis	.720
45	Katong-matsin	Chisocheton pentandrus	.725
46	Manaring	Lithocarpus soleriana	.736
47	Ipil-ipil	Leucaena leucocephala	.737
48	Bolong-eta	Diospyros pilosanthera	.743
49	Makaasim	Syzygium nitidum	.778
50	Alupag-amo	Litchi philippinensis	.793

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Table 2.--Composition of three chip mixtures of 50 Philippine hardwoods

Species[1]	Specific gravity range	Mixture composition[2]		
		A	B	C
		Pct	Pct	Pct
1 - 6	0.236 - 0.296	16.67	2	4
7 - 15	.308 - .394	16.67	4	8
16 - 24	.401 - .485	16.67	9	20
25 - 34	.510 - .597	16.67	15	40
35 - 42	.608 - .679	16.67	20	20
43 - 50	.718 - .793	16.67	50	8

[1]See Table 1 for names of the individual species.

[2]Moisture-free wood basis.

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Table 3.--Properties of 1/8-in.-thick, high-density hardboards

Chip mixture	Pulp yield	Resin content	Static bending[1]: Modulus of rupture	Static bending[1]: Modulus of elasticity	Internal bond strength	Tensile strength	Dimensional movement: From 50-90 pct relative humidity: Length	Dimensional movement: From 50-90 pct relative humidity: Thickness	Dimensional movement: From 50 pct relative humidity to water soak: Length	Dimensional movement: From 50 pct relative humidity to water soak: Thickness
	Pct	Pct	Lb/in.[2]	1,000 lb/in.[2]	Lb/in.[2]	Lb/in.[2]	Pct	Pct	Pct	Pct
				DRY FORMED--ASPLUND DEFIBRATOR PULP						
	90	4	7,230	684	326	4,380	0.18	6.66	0.22	19.01
	89	4	5,510	592	341	3,530	.18	6.36	.24	20.19
	90	4	6,900	691	326	4,400	.16	6.63	.21	18.15
, lights[2]	88	4	6,610	647	200	3,620	.22	6.63	.27	18.92
, heavies[3]	88	4	5,920	596	210	3,460	.20	7.39	.23	20.15
	80	4	4,220	539	286	2,240	.31	4.48	.50	12.53
, screenings[4]	79	4	2,960	459	221	1,620	.31	3.51	.52	11.75
, blend[5]	82	4	3,590	496	180	1,860	.30	3.78	.52	10.52
				DRY FORMED--BAUER PULP						
	--	2	7,560	704	213	4,270	.08	9.08	.08	24.11
	--	4	8,990	756	304	5,810	.09	7.76	.06	19.29
	--	2	7,200	661	197	4,350	.08	9.06	.10	26.04
	--	4	7,890	667	224	4,620	.07	9.31	.06	22.60
, heavies[3]	--	2	6,420	632	133	3,710	.08	9.41	.10	26.72
Do.[3]......	--	4	7,300	629	168	4,390	.07	9.17	.06	22.43
				WET FORMED--BAUER PULP						
	--	1	6,620	540	120	--	.17	12.63	.44	41.91
	--	1	5,720	474	102	--	.18	13.94	.48	46.87
, heavies[3]	--	1	4,950	426	73	--	.18	14.61	.49	50.97

[1] All values adjusted to 60 lb/ft^2 density.

[2] Air classified, less than 0.5 specific gravity

[3] Air classified, greater than 0.5 specific gravity.

[4] Oversize and undersize chip screenings.

[5] 50/50 blend of chip screenings and chips.

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Table 4.--Properties of dry-formed, medium-density hardboards from Bauer-refined pulp

Chip mixture	Resin type	Condition at test	Static bending[1]: Modulus of rupture	Static bending[1]: Modulus of elasticity	Internal bond strength	Tensile strength	Dimensional movement: From 50-90 pct relative humidity: Length	Dimensional movement: From 50-90 pct relative humidity: Thickness	Dimensional movement: From 50 pct relative humidity to water soak: Length	Dimensional movement: From 50 pct relative humidity to water soak: Thickness	Thickness swell after 24-hr water soak
			$Lb/in.^2$	1,000 $lb/in.^2$	$Lb/in.^2$	$Lb/in.^2$	Pct	Pct	Pct	Pct	Pct
			3/4 IN. THICK, 42-LB/FT^3 DENSITY								
A	Urea--6 pct melamine	Dry	3,910	408	120	2,650	0.20	7.29	0.30	25.01	26.61
B	do	do	3,580	420	104	2,300	.16	7.51	.31	25.98	27.85
B, heavies[2]	do	do	3,640	405	94	2,450	.18	6.70	.31	24.34	28.76
Do.[2]	do	Wet	2,540	248	--	--	--	--	--	--	--
Do.[2]	Urea--35 pct melamine	Dry	3,510	377	132	2,550	.19	7.13	.25	18.26	27.72
Do.[2]	do	Wet	2,570	238	--	--	--	--	--	--	--
Do.[2]	Urea--15 pct melamine	Dry	3,800	387	136	2,770	.17	7.21	.23	19.76	28.09
Do.[2]	do	Wet	2,710	251	--	--	--	--	--	--	--
			AVERAGE OF 3 U.S. COMMERCIAL MEDIUM-DENSITY HARDBOARDS, 44-LB/FT^3 DENSITY								
--	--	Dry	4,880	506	153	2,773	[3].47	--	--	--	3.41

(Sheet 1 of 2)

Chip mixture	Resin type	Condition at test	Static bending[1]: Modulus of rupture	Static bending[1]: Modulus of elasticity	Internal bond strength	Tensile strength	Dimensional movement: From 50-90 pct relative humidity: Length	Dimensional movement: From 50-90 pct relative humidity: Thickness	Dimensional movement: From 50 pct relative humidity to water soak: Length	Dimensional movement: From 50 pct relative humidity to water soak: Thickness	Thickness swell after 24-hr water soak
			Lb/in.^{2}	1,000 lb/in.^{2}	Lb/in.^{2}	Lb/in.^{2}	Pct	Pct	Pct	Pct	Pct
			7/16 IN. THICK, 48-LB/FT^3 DENSITY								
A	Phenol-resorcinol	Dry	4,730	477	150	2,710	0.14	5.70	0.17	11.59	12.63
A	do	Wet	3,430	290	--	2,160	--	--	--	--	--
A	do	Aged	2,540	183	44	--	.21	4.52	.29	9.55	[4]14.71
B	do	Dry	4,170	441	221	2,830	.13	5.90	.20	11.20	12.43
B	do	Wet	3,070	272	--	2,210	--	--	--	--	--
B	do	Aged	2,540	188	78	--	.22	4.67	.28	8.93	[4]19.29
A	Urea--35 pct melamine	Dry	4,480	409	143	3,050	.19	6.74	.29	18.68	13.58
A	do	Wet	2,650	210	--	2,140	--	--	--	--	--
A	do	Aged	490	36	2	--	.34	3.85	.47	--	--
B	do	Dry	4,470	426	184	2,980	.18	6.31	.25	16.47	13.68
B	do	Wet	3,000	242	--	2,020	--	--	--	--	--
B	do	Aged	620	50	5	--	.38	4.15	.54	13.05	--
			1/2 IN. THICK, 50-LB/FT^3 DENSITY								
B	Phenol-resorcinol	Dry	4,900	478	248	3,220	.17	6.72	.25	13.13	14.16
B	Urea--35 pct melamine	do	4,800	427	175	3,340	.19	7.46	.27	20.25	15.26

[1] All values adjusted to either 42-, 48-, or 50-lb/ft^3 density (except for aged specimens).

[2] Air classified, greater than 0.5 specific gravity.

[3] Linear expansion from 30 to 90 pct relative humidity.

[4] Based on original thickness, before aging.

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